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EXPEDITIONARY RUBBER REMOVAL CAPABILITY

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14. ABSTRACT

The Airfield Operating Surfaces team from the Air Force Research Laboratory (AFRL/MLQD) conducted research to examine the feasibility of using a small lightweight airfield rubber removal equipment package that could be used in expeditionary environments. The equipment package was built around detergent rubber removal techniques. An equipment package consisting of a single Toolcat with broom and sprayer attachments augmented with a 1,000 gal water trailer and 1,500 gal water truck achieved a production rate of 91,000 sf in 5.75 hrs on asphalt and 75,000 sf in 6.5 hrs on concrete while removing 90% to 95% of the rubber deposits. These rates are equivalent to 95% and 70% of the production rates of commercial companies with large equipment packages.

A detailed parts list of all the equipment used to reach these rates is included in appendix A. The cost of one fully equipped Toolcat is approximately $45,000. The cost of one water tender trailer with wash down nozzles is approximately $20,000. A set of bristles for the broom costs approximately $1500 plus shipping. The Avion 50 costs between $530 and $630 plus shipping for a 55 gallon drum. Avion 50 can be obtained in air shippable 5 gallon pales for approximately $90 per pale plus shipping.

A C-130 transportable package is proposed. This package contains two Toolcats with brooms and spray booms, bladders, pumps, hoses, and enough Avion 50 to clean 360,000 sf. The bladder, pumps and hoses will be placed on four host vehicles/trailers to create sufficient water support.

15. SUBJECT TERMS

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1. EXECUTIVE SUMMARY

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2. SCOPE

2.1. The purpose of this effort was to evaluate the feasibility of using a lightweight rubber removal capability package that will adequately accomplish rubber removal on runways in contingency environments. The package needed to be C-130 transportable. The package needed to attain a production rate of at least 40,000 sf per 6 hr period, 40% of existing commercial capabilities per broom vehicle (Toolcat). The equipment should be selected to minimize the training required to safely operate. The equipment and technique had to minimize the risk of damaging the existing pavement. Maximum use of commercial off the shelf equipment was desired. Equipment that could be used for other pavement maintenance tasks was also desired. The Avion 50 manufacturer's recommended procedures were used in all tests. These procedures were optimized for 6 hrs of runway access.

2.2. The primary objectives were to:

2.2.1. Determine the equipment with the highest probability of success in performing rubber removal while maintaining low weight and cube characteristics.

2.2.2. Identify other possible uses for the equipment package if successful in performing rubber removal (i.e. paint stripping, saw cutting, grinding, mixing, etc.).

2.2.3. Assemble package for field testing of rubber build-up on Air Force runways.

2.2.4. Test the equipment package on both Asphalt Concrete (AC) and Portland Cement Concrete (PCC) runways.

2.3. This report summarizes the method used for rubber removal as well as the results of testing, problems encountered, recommendations, and other possible uses. The results of this report can be used to:

2.3.1. Determine the viability of using a smaller equipment package for rubber removal in contingency environments.

2.3.2. Identify improvements that could be made to the package.

2.3.3. Provide procedures to perform rubber removal with the equipment.

3. BACKGROUND INFORMATION

3.1. General Description of the Removal Process:

There are two primary methods for removing rubber on runways. One method uses high or ultrahigh pressure water (high pressure 3,000 – 15,000 psi, ultrahigh pressure 25,000 – 40,000 psi) to dislodge or blast the rubber off of the pavement surface. The second method uses high alkali detergents combined with scrubbing action with wire brushes to remove the rubber.

The ultrahigh pressure water method requires specialized equipment and experienced operators. The Combat Training Site (CTS) at Ramstein Germany has a vehicle equipped to employ this method and has personnel that can instruct others on its use. It is known that the use of the ultra high pressure water method causes polishing of the aggregate and damage to the pavement surface, particularly on grooved pavements. Due to these concerns a detergent removal method was used for this effort. However, it should be noted that the pressurized water method offers greater flexibility with regard to runway closure times and allows the runway to rapidly return to full service in the event of an emergency in the middle of the rubber removal operation.

The detergent process used in these tests is the process recommended by Chemtek, Inc and is similar to that employed by other manufactures. This process was optimized for six hours of airfield access. Therefore, the tests were conducted with a target time of six hours. Possible adjustments to the process to reduce time, increase production, and decrease water requirements are discussed in the discussion portion of this report. However, due to the limited nature of the testing, these adjustments have not been tested and the effect that these will have on the quality, quantity, cost, or timing of the rubber removal process is not precisely known.

AFRL used Avion 50, a detergent that is widely accepted by industry and the Air Force, for rubber removal operations. Avion 50 is a liquid produced by Chemtek Inc. and was used in all tests; however, there are other similar products that are commercially available. This particular detergent is considered environmentally friendly and may be rinsed off the shoulders of a runway without reclamation (except in California). This method can be utilized in California; however, the rubber must be reclaimed in the process. Avion 50 costs between $530 and $630 plus shipping for a 55 gallon drum. Avion 50 can be obtained in air shippable 5 gallon pales for approximately $90 per pale plus shipping. You will require 55 gallons of Avion 50 for every 10,000 square feet of pavement to be treated. Note: Avion 50 is caustic. The primary ingredient is Sodium Hydroxide and has a PH of 13. PPE should be used when handling and eyewash should be readily available.

The primary steps were followed during the rubber removal process at each location:

3.1.1. Apply Avion 50 over the area to be cleaned at a rate of 55 gallons per 10,000 square feet.

3.1.2. Agitate the Avion over the entire cleaning area using a sweeper for 2 hours and 30 minutes. Care should be taken to keep the area damp during the agitation process.

3.1.3. Add a sufficient amount of water to pavement to cause the Avion 50 to foam. Continue agitation and foaming for 30 minutes. The rubber particles are suspended in the foam which aids in the rinse process. Note this final 30 minutes of agitation requires increased water application to facilitate foaming of the detergent agent.

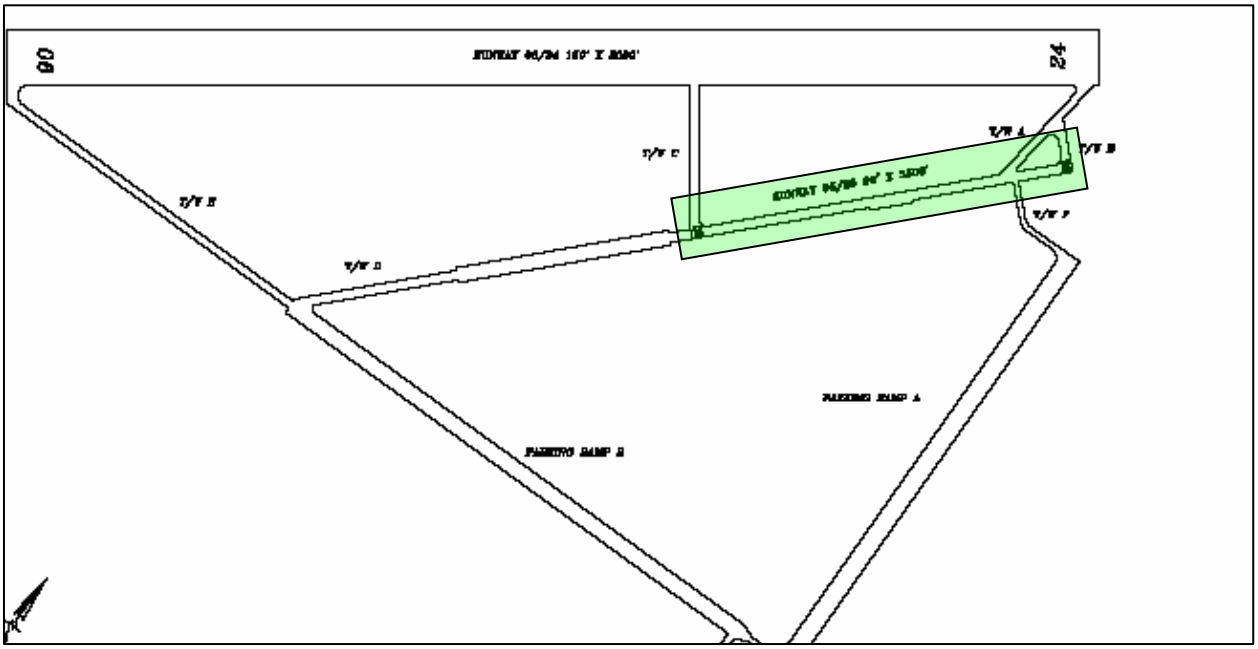
3.1.4. After the agitation process is complete the area should be rinsed with water at a rate of 3,000 gallons per 55 gallons of Avion 50 applied to the runway surface. A sweeper/broom should be used to assist in the process of moving the material to the sides of the runway.

3.1.5. A sweeper with a non metallic broom pack and a pick-up magnet should be utilized to sweep the runway to remove all loose metal bristles left behind from the cleaning operation.

3.2. General Description of the Runways Utilized for Testing:

3.2.1. North Auxiliary Field Assault Landing Zone (ALZ) 05/23 located in North, SC.

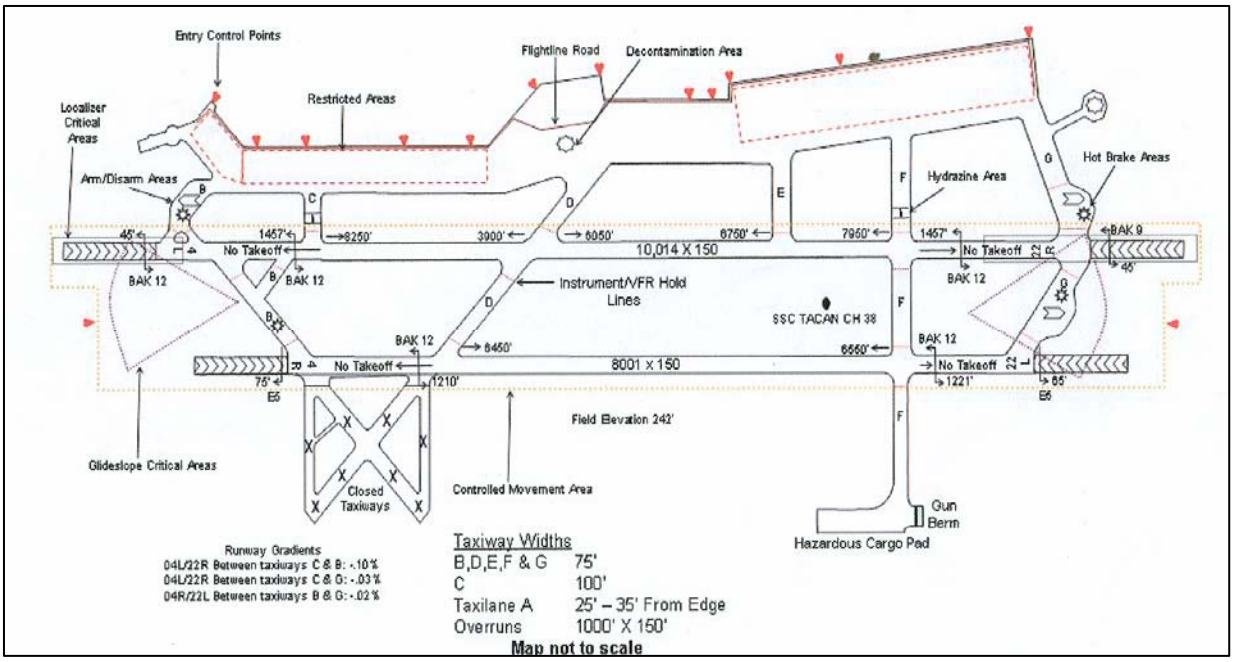
Length – 3,500’
Width – 90’
Surface – Grooved Asphalt
Grooves – 2 ½” OC x ¼” Wide x ¼” Deep
Rubber Build-Up – Medium to Heavy



3.2.2. Shaw AFB Runways 04R/22L and 04L/22R located in Sumter, SC.

Length 04R/22L – 8,000’
Width 04R/22L – 150’
Surface – Tinned Portland Cement Concrete
Rubber Build-Up – Light

Length 04L/22R – 10,000’
Width 04L/22R – 150’
Surface – Tinned Portland Cement Concrete
Rubber Build-Up - Light



4. EQUIPMENT PACKAGE

Two primary pieces of equipment were developed and are required as a minimum to properly remove rubber using this method. A tool cat with broom and skid loaded spray attachment and a nurse trailer with dust control spray nozzles. Several other piece of equipment while not required will greatly enhance the speed and quality of the job performed. These are enumerated in the discussion and recommendation portions of this report. The two pieces of equipment developed are used to perform tasks associated with seven separate essential functions. While many of these functions are similar, they require different volumes, flow rates and control to be effective. For example several of these functions involve dispensing water over the pavement; however, the amount ranged from disbursing several hundred gallons over the work area over a two and one half hour period to dispensing tens of thousands of gallons over the work area in a few hours.

In general you need equipment to assist with seven essential functions during the rubber removal process. You need pumps or procedures to assist with the efficient transfer of Avion 50 and water from one location/container to another. A detergent applicator is needed to dispense the Avion 50 to the pavement at the rate of 55 gallons per 10,000 square feet. A broom/brush is needed to agitate the Avion 50 and loosen rubber from the pavement. A water applicator is needed to keep the Avion 50 surface damp to promote breakdown of the rubber, but not so much that the mixture is diluted too much or that it begins to foam during the initial agitation process. The quantity of water added can range from two to seven hundred gallons over a two and a half hour period, depending on several factors such as temperature, humidity, and surface texture. Water is also needed to promote foaming of the Avion 50, but not so much that the mixture is rinsed off the pavement. The quantity of water added can range from four to six hundred gallons over a thirty minute period, depending on temperature, humidity, and surface texture. This usually can be accomplished with one pass/coverage using the detergent applicator on the

Toolcat to apply the water at 23 gal per minute driving at a speed of approximately seven MPH. A water applicator is also needed to rinse the rubber/Avion 50 slurry from the pavement. The quantity required can range from 15,000 to 27,000 gallons depending on the slope of the runway and the pavement surface texture. A broom is needed to assist with the movement of the foam and rinse water off of the pavement. These functions are enumerated here so that the reader may elect to utilize other pieces of equipment to perform some of these functions if conditions require a departure from the equipment package developed or recommend in this report.

4.1. Toolcat:

Specifications
56 HP Kubota Turbo Diesel
Dimensions with out attachments: 151” long X 63” wide X 81” tall
Dimensions with broom attachment only: 212” long X 96.75” wide X 81” tall
Dimensions w/broom, modified spray kit & boom: 243” long X 96.75” wide X 90” tall
Weight – 4820 lb (No Attachments)
Top Speed – 18 mph
High Flow Hydraulics (Optional) – 26 gpm
Steering – All Wheel Steering
Cargo Max Load – 2000 lb
Enclosed Cab

The Toolcat manufactured by Bobcat was chosen for testing because of its versatility and size. The Toolcat is easily maneuverable in and around confined areas and also has a top speed of 18 mph. Its high flow hydraulic system and 2,000 lb cargo load capacity would allow it to perform other pavement repair tasks. The Toolcat platform will support a broom attachment and spray system simultaneously. This in conjunction with the enclosed cab makes it an excellent choice for the rubber removal effort. Additionally, the Toolcat could handle attachments such as the Graco paint stripper, concrete saws, grinders, and mixers to perform other pavement maintenance tasks.

4.2. Broom Attachment:

Specification

Model: 84 inch angle broom

Hydraulic drive: 15 – 28 GPM Hydraulic direct drive

Broom angling: Hydraulic

Operating Weight: 944 lbs (standard 50 wafer bristle configuration)
1060 lbs (recommended 90 wafer bristle configuration)

Bristle diameter: 10 inch ID, 32 inch OD

Dimensions: 61” long X 96.75” wide

The broom attachment was initially tested with the factory recommended number of steel bristles installed. After the first test area (65’ x 100’) was completed, the broom was loaded with a combination of steel and poly bristles as suggested by Chemtek Inc. representatives. The steel broom wafers are convoluted and are placed from the factory in a configuration that forms space between the wafers. The wafers can be rotated 90 degrees so that they do not have space between them. When the broom was repacked seven steel wafers were placed with no spacing, then one flat poly wafer, one convoluted steel wafer, and one flat poly wafer. This sequence was repeated until the broom spool was completely loaded. This roughly doubled the number of wafers loaded on the broom. The poly bristles are needed to increase the movement of water while the steel bristles provide the scrubbing action. The poly bristle wafers can be purchased flat or convoluted. We only used flat poly wafers in our tests. A flat bristle wafer must be placed on each end of the broom assembly.

4.3. Spray System:

Specifications Unmodified:
Model: Bobcat SPR75
Capacity: 75 Gallons, fill: via top cap
Weight: 282 lbs empty 1010 lbs full
Dimensions: 50.5“ long X 47.6” wide X 30.8” tall
Pump: 12 Volt/ 5.3 gallons per minute
Boom: 21 ft in three sections with 13 nozzles. The boom adds 31 inches to the Toolcat length when mounted in the receiver. The boom is easily removed from the receiver. The boom is 85 inches high when in the stowed position on the Toolcat receiver. The boom is 82” wide when in the stowed position and mounted on the Toolcat receiver.
Maximum boom spray pressure: 40 psi

Modified Specifications: (Appendix A contains drawings & details of the modifications made, including a list of parts required)
Capacity: 200 Gallons, fill: via top or onboard pump assisted (105 – 170 GPM)
Weight: Approximately 300lbs empty, approximately 2000 lbs full
Dimensions: 61” long X 42” wide X 52.5” tall (90” when mounted on the Toolcat)
Pump: 5.5 HP gasoline powered, self priming, 105 – 170 GPM, 50 psi max pressure
Boom: Bob cat sprayer boom. 21 ft in three sections with 13 (TEEJET TKSS-15) nozzles
Maximum boom spray pressure: 40 psi
Spray volumetric rate at minimum power: 23 Gallon per minute

The agricultural spray system option sold by Bobcat was purchased with the Toolcat for application of the detergent. The system did not provide enough volume for the detergent application rate needed for rubber removal. AFRL in cooperation with Chemtek Inc. modified the spray system to properly apply the detergent. The original sprayer supplied by Bobcat supplied less than 5 gallons per minute. The modified system supplies a minimum of 23 gallons per minute. The factory installed electric pump on the Toolcat was undersized and failed due to what appeared to be a faulty contact in the pump. The electric pump was replaced with a Red

Lion 5RLGF-8 gasoline powered pump. The rubber hose on the system was upsized from 1/2" diameter to 3/4" diameter to supply enough volume to the nozzles on the system. The spray nozzles were replaced with tips that formed droplets instead of a mist to prevent excessive loss of the detergent due to wind. The new nozzles used were TeeJet TKSS 15 tips. The 75 gal holding tank was also replaced with a 200 gal tank; to extend working time. The plumbing on the system was modified so the pump could be used to fill the holding tank with Avion 50. This drastically reduced the time required to refill the tank by eliminating the use of a hand pump. Fill time with the gasoline powered pump is approximately five minutes.

4.4. Nurse Trailer:

Specifications (model PBM –DT-EL-1000-trailer) from PBM Supply & Mfg, Inc.
Dual axle trailer with electronic brake system
Kubota Diesel Motor (power for pump) (OC95-E)
RED LION MP Self Priming Pump – 210 gpm (model 21372)
Tank Capacity – 1,000 gallon
Spray Heads – Four (Fan Spray Pattern) (two on rear and two on passenger side)
Dimensions: 183" long X 90" wide X 80" tall
Weight: approximately 5,500 lbs

The nurse trailer was purchased to provide water for the rinse process during runway rubber removal operations if tanker support was not available at a base. The trailer is equipped with four nozzles that improve the efficiency of the rinse operation. However, the nozzles were designed for dust suppression and not optimized for rinsing the pavement. The trailer aided in the rinse process, but would perform better with a higher flow rate pump system and larger storage capacity. The trailer was a valuable supplemental device because of its ability to direct the water flow to the shoulder of the runway. The ability to direct the water accelerated the rinse process by forcing the detergent off the runway. The water dispensing was supplemented with a 1500 gal water truck at North Field and a 2000 gal water truck at Shaw AFB.

5. RUNWAY RUBBER REMOVAL PROCEDURES

5.1. Layout of Area to be Cleaned:

The area to be cleaned should be sized to allow the selected equipment to keep the area damp during the entire agitation process. Temperature, winds, humidity should be factored into the size selection of the area.

Place a traffic cone at each corner of the area to be cleaned. These cones will show the broom operator where to apply the detergent and where to scrub. If operations are to be accomplished during nighttime hours glow sticks should be attached to the cones for visibility.

5.2. Equipment Preparation and Detergent Fill:

Locate a water source (fire hydrant, water buffalo, or fill stand) on the airfield; the closer it is to the cleaning area the better.

Fill all tanks with water prior to starting any operation in order to identify any potential problems with water supply.

Test the spray equipment and the broom attachment prior to filling the holding tank with detergent.

Fill the tank to the level required to clean the specified area of rubber build-up. Note that it may require multiple fills to cover the entire area to be cleaned.

5.2.1. Detergent Fill Process

The first test utilized a hand power pump to fill the application tank. This proved to be too slow for the program objectives. The modifications made to the spray system incorporated a means to fill the holding tank directly from the 55 gallon drums without a separate transfer pump. This is done using a pick up tube and the principles of venturi action.

(With the pump running) Place the pick up tube in the drum.
Open the valve between the pump outlet and the tank.
Close the valve located in the hose between the holding tank and the pump intake.

Open the valve for the pick up tube.
If suction does not begin immediately, open the valve between the holding tank and the pump inlet half way to allow the Venturi action to start the flow. Once the suction line from the barrel is full, close the valve from the holding tank and pump intake.
Drain the barrel.

Note: Once the barrel is empty, close the valve for the pick up tube off while the hose is still half full, and the next barrel will begin to empty with less effort.

5.3. Detergent Application (approximately 30 minutes):

Spray the required amount of detergent removal agent uniformly over area to be cleaned. A uniform application requires following a pattern until all of the detergent is dispensed. The pattern may vary depending on the width of the area to be cleaned on each side of the center line. The spray bar is 20' wide. Only 20' either side of the center line, you will simply alternate passes from side to side, keeping the inside tip of the spray bar on the center line. If you are to clean 30' to either of the center line, you will make the first pass per side with the inside tip of the spray bar on the center line, and the next pass per side with the outside tip of the spray bar on the outside line of the area to be cleaned. Alternate passes until all detergent has been distributed. A speed of 7 MPH was maintained during the application with the equipment used in this test. The application rate was approximately 23 gallons per minute with this equipment.

5.4. Agitation Process (2.5 hours):

Agitation should begin no sooner than 30 minutes after application of the cleaning detergent. The total agitation time is three hours. The first two and one half hours, it is very important not to over water or under water the area being cleaned. During this time the goal is to have a visible fine mist coming off of the broom. If there is no mist, then water needs to be applied to the runway using the Toolcat spray set up while agitating. If there is too much water you will see foam forming on the runway. If foam forms on the runway continue to scrub with out adding water.

It is critical to not let the detergent dry up. If you have uneven spots where an area is drying faster than others around it, you have to add water to the dry areas.

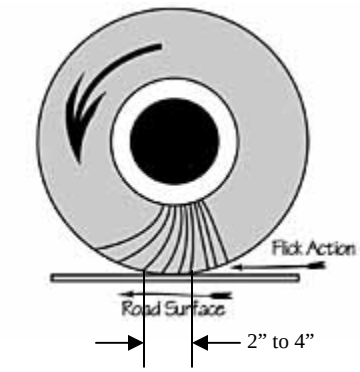
Agitation should be performed with the broom at an angle. Begin agitating with the broom angled toward the center line and the Toolcat positioned immediately to one side of the center line. After the first pass, turn around and come back down the center line on the opposite side (make a circle). Once that pass is complete you will continue making circles, each time widening the circle by ½ the width of the broom. You will continue these "circles" until all of the area has been agitated.

Upon the completion of the "circles" in one direction (from inside out) you will turn around and back track your previous circles moving from the outside in with the broom angle outward this time. This process will move the detergent around the surface of the runway with out sweeping it off. Restart the circles from inside out, then outside in, until you complete the agitation process. The foaming and agitation process will follow the same route, but will require that the sprayer be used to add water over the surface as you scrub.

5.4.1. Broom Pressure:

It is important to apply the proper broom pressure during the operation to reduce wear of the bristle and to increase the effectiveness of the scrubbing process. The bristles perform best by placing the tips in contact with the pavement surface, not the sides of the bristles. It is important to place just enough pressure, but not too much. To determine the proper downward pressure, you should perform the following steps:

1) Wet a portion of the surface to be scrubbed
2) Operate the broom with the broom positioned above the ground.
3) Note the RPMs on the Toolcat display
4) Lower the broom until the area contacted by the bristles is between 2" and 4" wide (see figure below).
5) Note the reduction in RPMs on the tool cat display
6) Lift the Broom and check to ensure the area scrubbed is 2" to 4" wide
7) Repeat until the desired 2" to 4" contact area is achieved.
8) Use the reduction in RPMs as a guide during the agitation operation to ensure the proper pressure is applied at all times.



5.4.2. Broom Alignment:

It is important to ensure the plane of the broom's horizontal pivot is parallel with the pavement. Failure to do so will result in uneven and excessive wear of the bristles and poor quality rubber removal when the broom is angled. The figure below shows the pivot point and the horizontal and vertical alignments.

5.5. Foaming and Agitation (30 minutes):

After the first two and one half hours of agitation, begin adding water to the runway on every pass. This will cause the detergent to build up foam. Continue agitating and building foam for the last 30 minutes of the three hour agitation process.

5.6. Rinse Process (approximately 2.5 hrs):

As a rule of thumb 3,000 gallons of water should be used to rinse every 55 gallons of detergent applied (3,000 gallons per 10,000 sf to be cleaned). The rinse operation is similar to the agitation process. The rinsing will be performed in a circular pattern starting to one side of the center line. The broom must be angled away from the center line in order to push the rinse water to the shoulder of the runway. At the beginning, the circle immediately adjacent to the center line should be repeated until that area is rinsed clean. During these tests, this required three passes. At that point, the circles should start being enlarged by ½ of the broom width, making sure that the areas rinse clean as you go. Once the broom makes it to the end of a pass, the rinse water should be swept to the shoulder before turning around.

In order to achieve the target of 3,000 gallons per 10,000 sf, the flow rate of the water coming from the water truck must be tied to the speed of the truck and the number of passes needed to get a clean rinse. The required gpm is given by the formula:

(gpm) = (86) x (mph) ÷ (# of passes).

For three passes and a speed of 7 mph a flow rate of 200 gpm is required. In practice, it is simpler to run the pump at max capacity and adjust the speed to match. In this case the speed is given by

(mph) = (gpm) x (# of passes) ÷ (86).

The pump on the nurse trailer in the tests was rated at 210 gpm.

Care should be taken when rinsing in areas where you have a taxiway or other runway crossing the runway you are treating. This tends to create an area where the longitudinal crown is reduced or no present. This can cause the rinse to pond if you attempt to rinse/broom in the longitudinal direction. At these locations you should rinse using the broom in the transverse direction instead of in the longitudinal direction.

5.7 Sweep with magnet

The final step in the rubber removal process is to sweep the cleaning operation area with a regenerative air sweeper. This should include the traffic path of all equipment to and from those areas. The sweeper should be loaded with non-metallic bristles and should have a pick-up magnet to remove all metallic FOD from the work areas. The purpose of this step is to remove any of the metal bristles that may have been left behind form the rubber removal equipment.

6. TEST RESULTS

6.1. Runway Rubber Removal Results:

Review of the pavements following the tests indicates that the process removed 90% to 95% of the rubber from the runway. Air Force standard practice is to remove at least 85%.

6.1.1. Test 1 - Grooved Asphalt – The ALZ at North Field was the first test for the new equipment. After the initial learning curve, the process went well. The rubber build-up on the ALZ was medium to heavy, and after cleaning there was no significant build-up left, only mild staining from aircraft operations. Feedback from the airfield manager and operations at North Field stated that the ALZ was as clean as they had ever seen after a rubber removal operation.

Test 1						
Section	Area	Time	Avion 50	Agitate Water	Rinse Water	Comments
	sf	Hrs	Gal	gal	gal	
1	6,500	3.3	40	500	4,500	
2	6,500	4	40	250	2,500	
3	19,500	5.25	110	800	7,500	
4	19,500	4.92	110	1,200	7,000	
5	65,000	6	275	1,000	15,500	
6	91,000	5.75	330	1,000	8,500	light residue noted
7	16,250	3.83	60	600	2,500	

6.1.2. Test 2 - Tinned Portland cement Concrete – The runways at Shaw AFB were cleaned with the same equipment as the previous test with no maintenance or upgrades performed. The runways had light rubber build-up, it should be noted that the lack of rubber build-up allows the detergent to be absorbed by the pavement. This absorption creates a different scenario for keeping the detergent damp and activated for rubber removal. So, although the build-up was not significant, it allowed the team members to test another possible condition with the equipment. Once again, the runway was cleaned leaving no build-up and only minor staining from aircraft traffic.

Test 2						
Section	Area	Time	Avion 50	Agitate Water	Rinse Water	Comments
	sf	hrs	gal	gal	gal	
1	44,000	6.5	200	1,200	11,000	
2	44,000	6	200	1,200	14,000	
3	75,000	8	400	1,400	21,000	rinse took 4 hrs
4	75,000	6	400	1,000	18,000	

6.2. Equipment Performance:

6.2.1. Equipment (North Auxiliary Field): The spray system had to be retrofitted/rebuilt on the fly due to failure of the off the shelf system. After the retrofit, the system worked without failure and performed well. The Toolcat experienced failure of the rear wheel

speed sensor and had to be serviced to remedy the problem. The nurse trailer performed well, but it was determined that it could not provide enough water for the process alone. The use of the 1,500 gallon isometric tanker provided by North Field was instrumental in the success of the cleaning process.

6.2.2. Equipment (Shaw AFB): The Toolcat performed well during operations at Shaw AFB. The Toolcat once again experienced problems with the rear wheel speed sensor. Upon return to Tyndall AFB the Toolcat was sent for service and the dealer found a factory defect in the wiring harness that caused the rear wheel sensor problem. The harness was replaced under warranty. The broom attachment began to make noise that was thought to be a bad bearing on the spool assembly; however, it was determined by the dealer that the spool was warped, creating the noise. The spool was also replaced under warranty. The nurse trailer did not pump enough water due to pump failure and was used by simply dumping water directly from the rear fill valve. The trailer worked only as a supplement to the 2,000 gallon tanker truck for rinsing procedures.

6.2.3. Bristles: Using the recommended broom packing sequence, we were able to successfully remove rubber from 172,000 sf of asphalt and 238,000 sf of concrete with one set of wafer bristles. The bristles had to be replaced after the testing at the second base.

7. DISCUSSION

7.1. Testing: Several problems were encountered during the testing that high light additional areas for improvement, or operational considerations that will need to be addressed by the airfield managers, local support staff, and the engineers performing the rubber removal. For example, during the testing on test section 3 at Shaw AFB, the rinsing process took much longer than normal and extended the project by two hours. This was due to the ponding of the rinse at a location where the taxiway crosses the runway being cleaned. It required some time to develop a method to deal with this issue. In the end the problem was solved by brushing transversely across the runway instead of longitudinally. However, this highlights the need to have a contingency plan to deal with situations where the operation may not go as planned, and could impact impinging flight operations. It is also possible that in an expeditionary environment, flight operations may have to resume earlier than expected, and plans must be in place to deal with that possibility.

7.2. Detergent Method of Rubber Removal: The detergent removal method is geared around a six hour treatment cycle. While steps can be taken to shorten this time slightly, it is unlikely the time can be decreased significantly and still be able to clean significant areas of the runway in a single session. The detergent removal method requires that the detergent remain in contact with the pavement surface for three and one half hours. Since this is a detergent reaction that takes time to complete, there is little that can be done to reduce the time required for this portion of the process. Furthermore, reductions in the surface area treated will have little effect on the time required for this portion of the process. Treating a smaller area will only allow the surface to be scrubbed more often. While this can decrease the time required slightly, experience has shown that contact time between the rubber and the detergent is the largest factor affecting rubber removal quality. The Toolcat has proven that it can be used to apply and agitate an area in

excess of 90,000 sf in the 3.5 hrs required. The rinsing portion of the process, 2.5 hrs, is most affected by equipment and technique. The rinsing capability will drive the production rate of any rubber removal operation.

7.3. Rinsing**:** The primary driver effecting the speed and efficiency of the rinse process is the availability of a steady stream of water. The most important factors affecting the ability to keep a steady stream of water available are the capacity of the water truck/trailer, distance to the water source, number of vehicles available, and the pump flow rate. In general, it is better to have two vehicles with smaller capacities each than one with twice as much capacity. For example, it is better to have two 1000 gallon nurse trailers than one 2000 gallon trailer. Doubling the number of trucks/trailers will double the amount of area you can rinse in a given amount of time (normally two and one half hours); however, doubling the capacity of a single truck/trailer will increase production by 50% if the water source is 3 miles away, 20% if the water source is 1 mile away, and have virtually no effect if the water source is a quarter of a mile away.

The flow rate of the pumps on the truck/trailer has an effect on the production rate and is tied to the velocity of the sweeper following the water truck and the number of passes required to rinse the surface. Most of the test sections required 3 passes to complete the rinse. Using the procedures used in this test you will require a pump rate of 28.6 gpm for each mile per hour of speed. For our tests we use 7 mph and 200 gpm.

Table one provides estimates of the maximum area that can be rinsed in 2.5 hrs given that a single water truck or trailer is available. The data is provided for storage capacities of 1000 to 3000 gallons. It also provides data for situations where the water source is located 3, 1, and 0.25 miles from the rinse area. Table two provides estimates of the maximum area that can be rinsed in two and one half hours, given that two water trucks or trailers are available. All data assumes a pump rate of 200 gpm

The pump rate has some effect on the production. By increasing the speed of the sweeper from 7 to 10mph and the pump rate to 290 gpm, you will achieve a 0 to 10,000 sf increase in production for a single truck/trailer and a 10,000 to 20,000 sf increase for two trucks/trailers.

The primary focus of the research was on the detergent rubber removal process, agent application, agitation, the performance Toolcat, and the rinsing process. During the test, the ability to direct the rinse water flow to the side of the runway had a noticeable impact on the ability to rinse the runway. The nurse trailer, while allowing the operator to direct the flow the nozzles were designed for dust suppression. Experience gained in these tests indicates that it may be possible to refine the design of the nozzle and pump system to develop a forced pressurized stream that could increase rinsing effectiveness, and potentially decrease rinsing time and water requirements. Furthermore, this pump and nozzle equipment could be designed to fit most any existing water truck/trailer.

Table 1: Rinse Areas for Single Water Truck/Trailer

Capacity of vehicle	Pump flow rate dump	Distance to fill stand	Average speed to fill stand	Cycle time	Cycles per 2.5 hrs rinse	Max 2.5 hrs rinse area
gallons	Gpm	miles	mph	minutes		sf
1000	200	3.00	30	24.20	6.20	20,000
1500	200	3.00	30	29.70	5.05	25,000
2000	200	3.00	30	35.20	4.26	25,000
3000	200	3.00	30	46.20	3.25	30,000
1000	200	1.00	30	15.40	9.74	30,000
1500	200	1.00	30	20.90	7.18	35,000
2000	200	1.00	30	26.40	5.68	30,000
3000	200	1.00	30	37.40	4.01	40,000
1000	200	0.25	20	12.65	11.86	35,000
1500	200	0.25	20	18.15	8.26	40,000
2000	200	0.25	20	23.65	6.34	40,000
3000	200	0.25	20	34.65	4.33	40,000

Table 2: Rinse Areas for Two Water Trucks/Trailers

Capacity of vehicle	Pump flow rate dump	Distance to fill stand	Average speed to fill stand	Cycle time	Cycles per 2.5 hrs rinse	Max 2.5 hrs rinse area
gallons	Gpm	miles	mph	minutes		Sf
1000	200	3.00	30	12.10	12.40	40,000
1500	200	3.00	30	14.85	10.10	50,000
2000	200	3.00	30	17.60	8.52	50,000
3000	200	3.00	30	23.10	6.49	60,000
1000	200	1.00	30	7.70	19.48	60,000
1500	200	1.00	30	10.45	14.35	70,000
2000	200	1.00	30	13.20	11.36	70,000
3000	200	1.00	30	18.70	8.02	80,000
1000	200	0.25	20	6.33	23.72	75,000
1500	200	0.25	20	9.08	16.53	80,000
2000	200	0.25	20	11.83	12.68	80,000
3000	200	0.25	20	17.33	8.66	80,000

7.4. Detergent: The Avion 50 does an excellent job of removing the rubber while minimizing the damage to the pavement and markings. Avion 50 weighs approximately 480 lbs per 55 gallon drum. On average the amount of rubber removal required is approximately 50,000 sf on each end, or 100,000 sf per runway. Therefore, ten 55 gallon drums (4,800 lbs) must be shipped

to the location per runway to be treated. The majority of the tests used the application rate of 55 gallons per 10,000 sf. Several areas with light rubber removal requirements were treated with Avion 50 at a rate of 55 gallons per 14,000 sf with a little degradation in quality. This was accomplished by diluting the Avion 50 and applying at the diluted mix at the same rate on these portions of the pavement.

7.5. Detergent Application: The detergent was staged on the ground in an area off of the runway. This required the operator to drive for several minutes to and from the staging are to refill the Toolcat. If some of the AVION 50 was staged on a truck that could be driven out to the area being treated, then the applicator can be refilled much more quickly and efficiently. The Toolcat can apply 400 gallons of Avion 50 to the pavement with only one refill needed. Using a 23 gallon per minute application rate, this can be accomplish in 18 minutes leaving 12 minutes for the refill process. 400 gallons equates to just over 70,000 sf. In order to fill and treat any areas larger than 70,000 sf with a single applicator, the detergent will have to be applied at a slightly faster rate, and the tank must be filled, or partially filled a second time. Alternatively the detergent could be applied at a reduction from the recommended rate, or the tank on the spray skid could be increased to 250 gallon. Chemtek Inc. has tentatively agreed to produce the modified spray system. Bobcat, Inc. has agreed to meet with AFRL to discuss medications to their spray system to meet Air Force requirements. AFRL is looking for other potential sources.

7.6. Agitation and Foaming Process: Traveling at 7 mph will allow the operator to foam and agitate 50,000 sf with one complete coverage allowing for 400 gallons of water. The operator will need to travel at 10 mph in order to treat 70,000 sf.

7.7. Water Quality: It is important to strain debris from the water when filling the tanks. Debris fill the strainer on the nurse trailer and caused the poor performance of the spray system in some of the tests. The in-line strainer should be checked/cleaned periodically to ensure peak performance.

7.8. Broom Pressure and Tilt: While an operational work around was developed to ensure the proper pressure and tilt (level) is applied at all times, a simple set of sensors and LEDs could be incorporated to the system to make it easier for the novice to achieve quality results. There were instances during the testing when the operator was unaware that the bristles were not touching the pavement and had to be notified by one of the observers to lower the broom. As a low tech alternative, casters could be placed on the broom to insure the proper pressure is applied. The casters would need to be adjusted at the end of each day to account of the wear on the bristles.

7.9. Cleaning and Maintenance: Avion 50 is caustic with a PH of 13. All equipment should be flushed and cleaned at the end of each session and prior to transport.

7.10. Logistics: 463L pallet can hold (12) 55 gallon drums (≈ 7,000 lbs), which will treat approximately 120,000 sf. The Avion 50 can be repackaged to weight out the pallet (10,000 lbs). This will load 1,000 gallons into one pallet position, which is enough to treat 180,000 sf. Chemtek states that the majority of rubber for most military bases they treat is in a section that is 50’ wide and 1500’ long (75,000 sf) at each end of the runway. Therefore, one pallet position should be more than enough to treat both ends of one runway.

The Toolcat can fit on a C-130 but it will require more than one pallet position. The spray pump and tank can be shipped in the bed of the Toolcat without increasing the foot print and stay within the height restrictions of the C-130. If the spray boom is shipped while in the Toolcat receiver, or the broom attachment is retained on the front receiver, it will increase the length of the space required to more than two pallet positions. It is recommended that configuration be examined to ensure the Toolcat and its attachments do not exceed more than two pallet positions.

The best option for water support is to secure two locally available water trucks (for each Toolcat) to support the operation. If that is not possible then the nurse trailer used in this test will fit on a C-130 but will require just over two pallet positions. However, there are several other options that could provide better support of the operation and use less than two full pallet positions. If vehicles with beds (dump truck) or flat bed trailers (low boy) can be secured at the host base then a system of bladders and pumps could be shipped in a single pallet position. Two or four 2500 gallon bladders along with pumps, nozzles and hoses could be shipped and set up on the trucks/trailers. Alternatively, poly tanks with 2000 gallon capacity could be nested and shipped in one pallet position along with pumps, nozzles, and hoses and placed on trucks or trailers at the destination. Some sources of bladders and tanks are listed in appendix B.

With a redesign of the water support capability, it is possible to develop a package that includes two fitted Toolcats (three pallet positions), with tanks/bladders, pumps, nozzles and hoses for four water support vehicles (one Tail pallet position, 4,664 lbs 86”X84”X76”), and enough Avion 50 for 360,000 sf (two pallet positions). Six pallet positions are used. This assumes that the spray bar booms and the broom attachment can be stored somehow in the same footprint of the three pallet positions used by Toolcats.

7.11. Production rate: The production rate is primarily influenced by the rinsing process, but in the ideal situation is also constrained by the detergent application and the agitation and foaming process. The planned production rate should be limited to less than 70,000 sf per Toolcat provided sufficient rinse capability is present. To reduce wear on the Toolcat, it is further recommended that the production be limited to less than 50,000 sf per Toolcat when possible. Use Tables one and two to find the constraints placed on the production rate based on rinse capability. For a package of one Toolcat and one 1000 gallon nurse trailer, the production rate should be limited to 20,000 sf per six hour period, or 30,000 sf if the water source is located more than a two minute drive from the treatment area.

7.12. Time on the airfield: The tests performed under this effort were focused on evaluation of these tools vs commercial equipment. Therefore, the testing targeted a six hour process. It is known that operations in expeditionary environments may limit access to the airfield even further. Engineers are often limited to four hours or in some cases they are limited to 2 hrs on the airfield.

The results of the tests conducted indicate the agitation time for areas less than 16,500 sf can be decreased by 30 minutes and still meet Air Force standards. Furthermore, the tests demonstrated that a single Toolcat can successfully treat 16,500 sf within four hours. The data

indicates that a single Toolcat can treat up to 40,000 sf in four hours if the correct rinse water support is available.

The process can not be completed as designed in less than three hours for any amount of pavement; therefore, the process would have to be altered and validated when faced with this added constraint.

The process has been formulated to maximize the benefit from the detergent reaction and minimize the scrubbing or mechanical effort required. Chemtek's experience has shown that additional mechanical effort can decrease the amount of time required on the airfield. However, doubling the mechanical effort does not cut the required time to achieve the same removal in half. Discussions with Bobcat and United Rotary Inc (http://www.united-rotary.com/) indicate that flat steel wafer bristles that fit the broom attachment can be special ordered. If flat wafers are used in lieu of the convoluted wafers 40% more bristles can be added; thus increasing the mechanical effort by 40%. Furthermore, the number of bristles on each steel wafer can be doubled thereby doubling the mechanical effort.

Discussions with Chemtek indicate that some airfields with similar constraints treat the surface for only two hours achieving only 50% rubber removal during the treatment. They treat the same area a second or third time to achieve the level of rubber removal required. The obvious downside is that two to three times as much Avion is required to treat the same area.

If a process optimized for two hours on the airfield is required, then additional development and testing is required to create an optimum solution.

7.13. Magnet on Sweeper: The regenerative air sweeper used for final clean up should be fitted with a magnet to pick up all metal FOD left behind by the rubber removal equipment. In addition to removing FOD left from the cleaning operation it also acts as a redundant safety measure.

7.14. **A**dditional improvements: In addition the improvements enumerated in the discussion provided in this report, several concepts regarding the detergent application and agitation process have been discussed with several rubber removal experts. These alter the sequence of application, scrubbing and foaming and may potentially lead to increased production over shorter periods of time. One proposal will apply Avion 50 and begin agitation 20 minutes later. Additional Avion 50 will be added during the agitation, then foaming beginning on the third coverage, with the potential of decreasing the total agitation time to one hour, followed by rinsing for 40 minutes. This new sequence has not been tested.

8. CONCLUSIONS

The Toolcat is capable of 70% to 95% of what a commercial vender can accomplish is a six hour session. The actual amount will vary depending on the amount of rubber and the environmental conditions.

8.1. The quality of the removal process met or exceeded the requirements of the Base Operations and the Airfield Managers at the bases.

8.2. The Toolcat is a viable option as a platform for a lightweight rubber removal equipment package.

8.3. The custom built nurse trailer proved to be inadequate by itself for rinse operations during rubber removal. However, it was adequate to support the refill operations of the Toolcat during the agitation and foaming process.

8.4. The retrofitted spray system places an ideal volume and pattern of detergent agent on the paved surface for cleaning. Furthermore, the modified system increased the efficiency of the detergent fill process five to ten times.

8.5. The rinse process is most efficient when a steady flow of water is available.

9. RECOMMENDATIONS

9.1. Develop a concept of operations in conjunction with airfield managers and operations experts to ensure all issues associated with airfield maintenance in contingency operations are considered. In particular, each base should have a plan to allow for emergency flight operations, with the understanding of the caustic nature of the detergent removal process.

9.2. Limit rubber removal effort to 70,000 sf or less in one six hour period with a single vehicle Toolcat (applicator/broom vehicle).

9.3. When possible, ensure you have a backup broom and detergent applicator, preferably a second Toolcat. The second Toolcat can be on standby or actively removing rubber on the runway.

9.4. Use a truck to carry the Avion 50 to the airfield so that the detergent applicator spray unit can rapidly be refilled on the airfield. This will cut out the travel time on and off the runway to refill during the detergent application process.

9.5. Ensure you have a nurse tank or water truck to supply the Toolcat on the runway during the agitation and the foaming process. This will minimize the time needed to refill the tank on the Toolcat.

9.6. The gasoline powered pump on the Toolcat sprayer should be replaced with a hydraulically operated pump or diesel powered pump with the same flow rate as the gasoline powered pump. No changes are necessary for the hoses and spray nozzles on the modified system.

9.7. AFRL should contact vendors to locate or develop a commercial source of the modified spray unit or system with equivalent capabilities.

9.8. A pressure sensor or caster wheels should be incorporated into the broom attachment to allow the operator to consistently place the broom on the paved surface at the correct pressure. As a work around the operator can calibrate the proper down pressure with a reduction in the RPMs as the broom is brought in contact with the pavement. AFRL will design the sensor, casters and or develop RPM reduction curves for various surfaces if tasked.

9.9. The broom should be re-packed with 80% steel and 20% poly wafers using the following bristle wafer pattern instead of using the pattern provided by Bobcat: 1 Poly (P), 7 Steel (S), 1 P, 1 S, 1 P, 7 S, 1 P, 1 S, 1P, 7 S, 1 P, 1 S, 1 P, 7 S, 1 P, 1 S, 1 P, 7 S, 1 P, 1 S, 1 P, 7 S, 1 P, 1 S, 1 P, 7 S, 1 P, 1 S, 1 P, 7 S, 1 P, 1 S, 1 P, 8 S, 1 P. 90 wafers total, 72 convoluted steel, 18 flat poly. AFRL will evaluate the use of flat steel wafer bristles and formulate a new pattern if tasked.

9.10. Utilize two portable water devices (nurse tanks, collapsible tanks, water trucks etc.) during the rinse process for each Toolcat. This will allow one vehicle to dump while the other is refilling.

9.11. Utilize 1500 gallon or higher capacity portable water devices for the rinse process.

9.12. Design a new system of portable water devices that can fit on one pallet to replace the 1000 gallon nurse trailer. AFRL will design, construct, and test this system if tasked.

9.13. Investigate and develop a nozzle system optimized for the rinse process to reduce the water requirement and increase the efficiency of the rinse process. AFRL will develop the nozzle system if tasked.

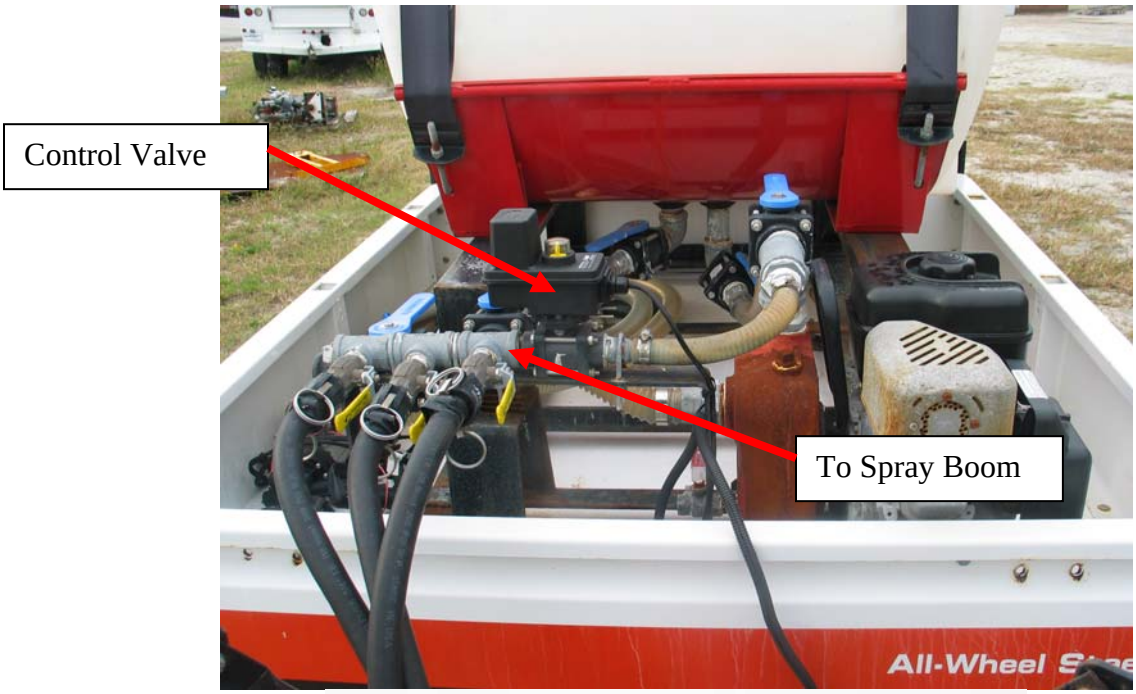
9.14. In conjunction with aerial port and load master experts, develop a load plan for the rubber removal kit. AFRL will develop the plan if tasked.

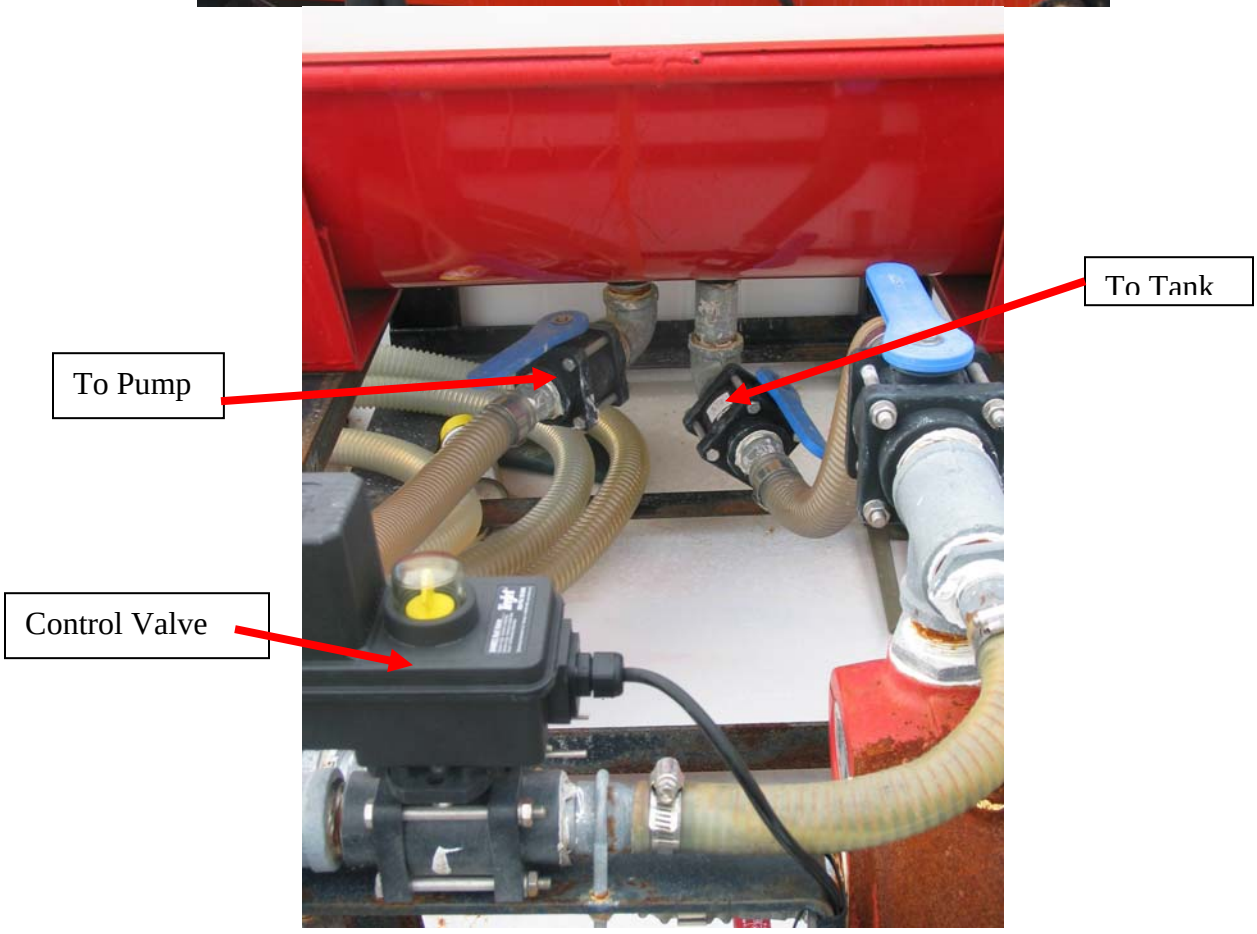
9.15. Examine methods to achieve the needed removal quality with time on runway limited to four and two hrs, if these shorter access times are required. This will require additional development and testing.

9.16. An additional safety measure for the rubber removal equipment package would be to add pick-up magnets to the Toolcat and water trucks. The magnets would aid in the removal of metal bristles left behind during the cleaning process.

APPENDIX A
DETAILED LIST OF EQUIPMENT AND MODIFICATIONS

Quantity	Part Name	**Description** (system as tested)	Vendor / Source	Part #	Est. Cost ea.
1 ea.	Pump	Red Lion, 5RLGF-8, 170 gal/min, max. 50 P.S.I.	Redlionproducts.com	5RLGF-8	$450.00
1 ea.	200 gallon holding tank	200 gallon poly cylindrical tank	Watertanks.com	040-055	$330.00
1 ea.	saddle and cradle set	200 gallon applicator saddle and cradle set	Watertanks.com	024-100	$410.00
1 ea.	Solenoid valve	Teejet 344BEC	Farmchem.com	344BEC-23-C	$160.00
2 ea.	Holding tank fittings	1-1/2" dia fiitings for the bottom of the holding tank			
2 ea.	1-1/2" - 90's	1-1/2" NPT 90 degree pipe fittings, galvanized			
7 ea.	1-1/2" ball valve	1-1/2" polypropylene ball valve	Agri Supply	10196	$19.95
60 feet	Suction hose	Tigerflex WT150, 1-1/2" suction hose (per foot)	plastixs.com	WT150	$2.05
15 ea.	1-1/2" nipples	1-1/2" x 3" NPT nipples, galvanized			
2 ea.	1-1/2" "T"	1-1/2" NPT - "T" fitting, galvanized			
100 feet	3/4" I.D. spray hose	EDPM black sprayer hose 3/4" x 100', roll	Agri Supply	32557	$68.95
3 ea.	3/4" "T"	3/4" NPT - "T" fitting, galvanized			
10 ea.	3/4" nipples	3/4" x 3" NPT nipples, galvanized			
1 ea.	3/4" plug	3/4" NPT plug, galvanized			
3 ea.	3/4" ball valve	3/4" brass body ball valve			
1 ea.	1-1/2" 90 degree coupler	1-1/2" type D, 90 deg. Female coupler, NPT, cam action	Agri Supply	10264	$8.49
2 ea.	1-1/2" male adapter	1-1/2" type A male adapter, NPT female thread	Agri Supply	10246	$2.49
1 ea.	1-1/2" female adapter	1-1/2" type D, Female adapter, NPT, cam action			
3 ea.	3/4" female coupler	3/4" type D female coupler, NPT, cam action	Agri Supply	10213	$5.49
3 ea.	3/4" male adapter	3/4" Ttype A male adapter, NPT, cam action, fem thread	Agri Supply	10210	$2.29
13 ea.	spray tips	Teejet TKSS-15	Farmchem.com	TKSS-15	$5.80
10 ea.	Nozzle body	3/4" double hose nozzle body	Agri Supply	32518	$4.49
3 ea.	Nozzle body	3/4" single hose nozzle body	Agri Supply	32519	$4.49
13 ea.	cap and gasket	Nozzle body cap and gasket for Teejet TK series	Agri Supply	28767	$0.69
13 ea.	boom clamp	1" square metal boom clamp	Agri Supply	22640	$1.29
a/n	hose clamps	clamps for 3/4" hose			
a/n	hose clamps	clamps for 1-1/2" hose			
1 ea.	spray bar	spray bar available from Bobcat for Toolcat 5600	Bobcat		$400.00
1 ea.	mounting frame	custom made mounting frame for pump system			


Control Valve
To Spray Boom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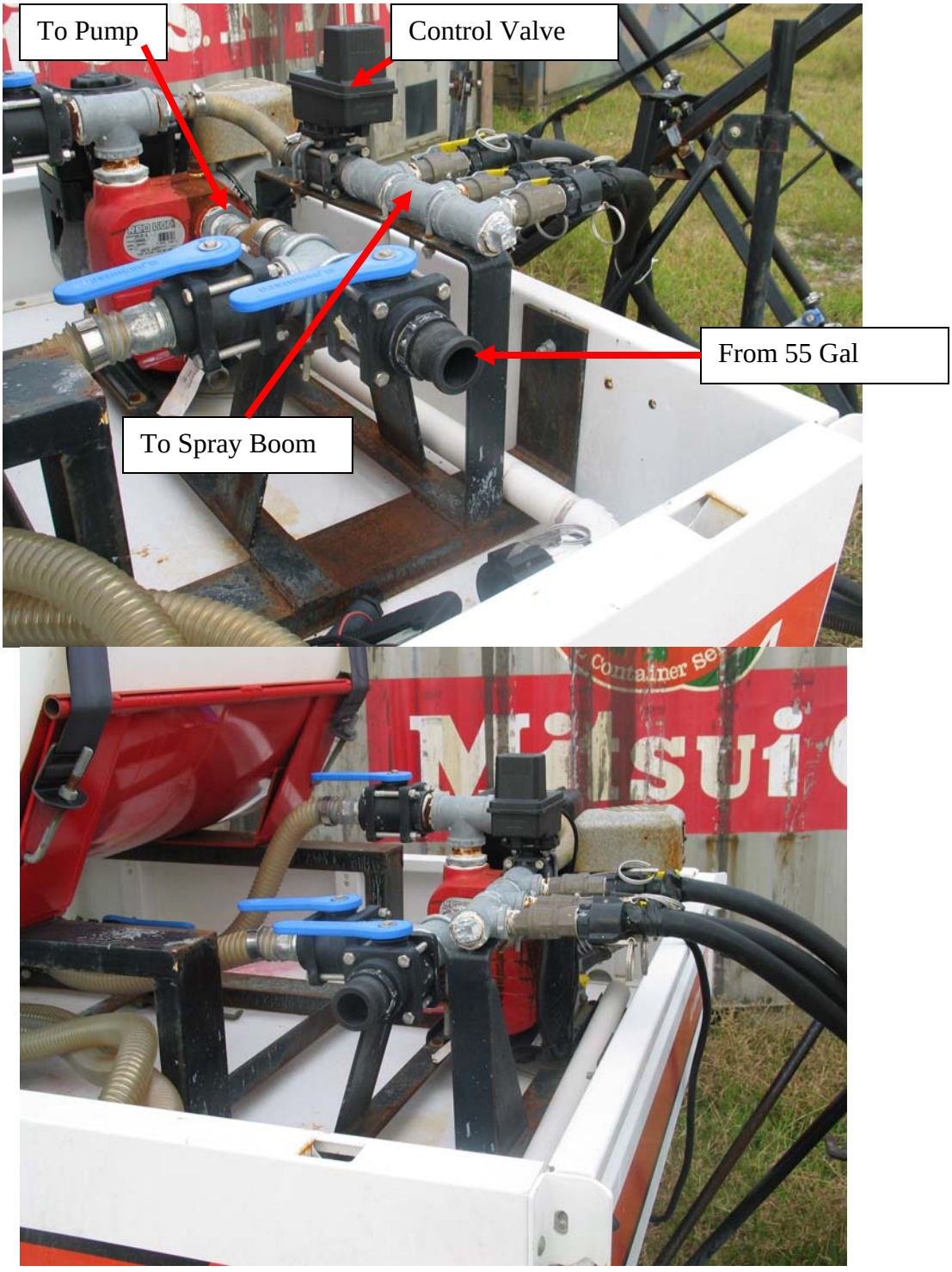
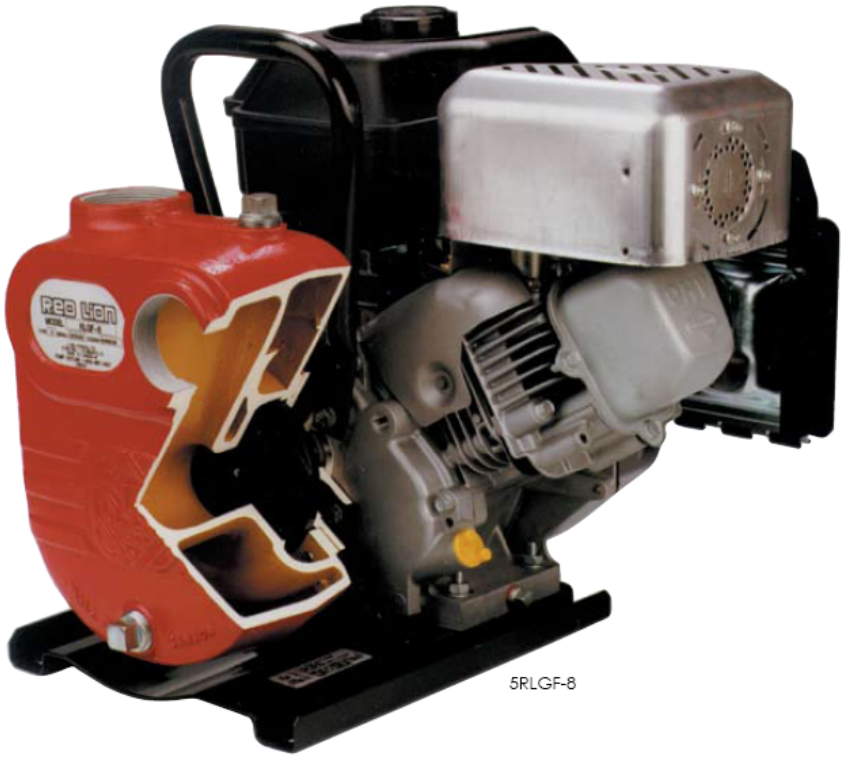

To Pump
Control Valve
From 55 Gal
To Spray Boom

RLGF Series
Multi-Purpose Utility Pump



5RLGF-8

Applications:
Ideal for liquid transfer including most agricultural chemicals and general dewatering where rugged portability is important. The 5.5 HP engine is for high specific gravity fluids.

Features:
- Heavy duty cast iron pump casing.
- Durable cast iron semi open type impeller.
- Stainless steel shaft sleeve and Viton seal.
- 2" NPT suction & discharge for convenient hookup.
- Briggs & Stratton engines; 3.5 HP (standard) or 5.5 HP (*INTEK*) .
- Self priming down to 25 feet.
- Flow rates to 170 U.S. gallons per minute (5.5 HP).
- Handles most liquid agricultural chemicals.
- Handles up to 5/8" solid debris
- 1 Year over-the-counter warranty.


Motor Shaft Vent Holes
Prevent damage to motor by diverting water away from engine in the event of a seal failure.

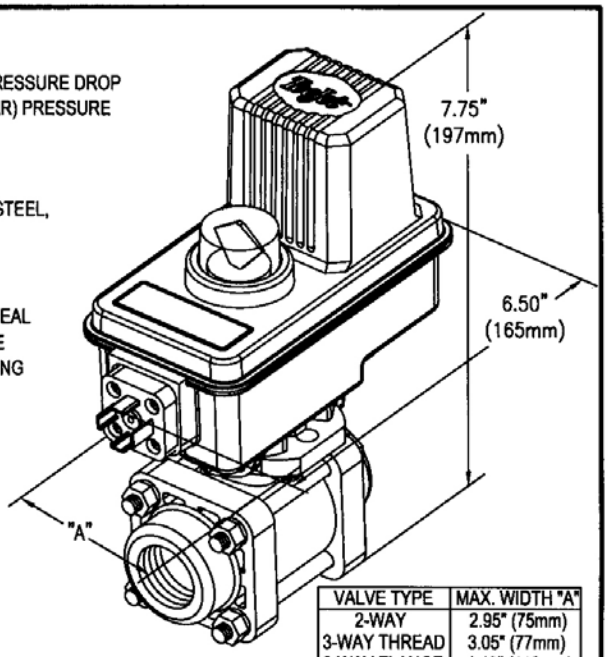
Pump Model	HP	Pump Capacity in U.S. GPM Pumping Height in Feet							Max. Press. (PSI)
		20	30	40	50	60	70	80	
RLGF-8	3.5	140	132	120	105	85	63	37	39
5RLGF-8	5.5	170	165	155	150	140	125	105	50

Model No.	Order No.	UPC	HP	Ship Wt. (lbs.)	Length	Width	Height	Carton Cubes (cu. ft.)
RLGF-8	616808	085635-16808-0	3.5	65	17.6"	16.75"	16.1"	2.75
5RLGF-8	616806	085635-16806-6	5.5	70	17.6"	16.75"	16.1"	2.75
HOSE KIT	640206	085635-40206-1	-	20	24.75"	12.75"	27"	4.93

* When ordering parts, order Repair Kit #697120.

SPECIFICATIONS:

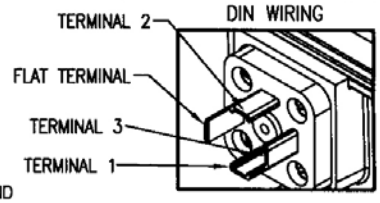
- MAXIMUM PRESSURE RATING: 300 PSI (20 BAR)
- FLOW RATE: 32 GPM (121 L/MIN) @ 5 PSI (.34 BAR) PRESSURE DROP FOR 2-WAY VALVE; 24 GPM (91 L/MIN) @ 5 PSI (.34 BAR) PRESSURE DROP FOR 3-WAY VALVE
- RESPONSE TIME: 0.6 SEC. FROM CLOSED TO OPEN
- CURRENT DRAW: 1.34 AMPS NOMINAL @ 13.8 VDC
- MATERIALS: POLYPROPLYENE, NYLON, STAINLESS STEEL, TEFLON®, AND VITON®

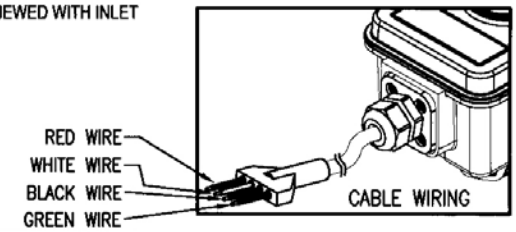


VALVE TYPE	MAX. WIDTH "A"
2-WAY	2.95" (75mm)
3-WAY THREAD	3.05" (77mm)
3-WAY FLANGE	4.40" (112mm)

FEATURES INCLUDE:

- BUILT-IN DIN CONNECTOR (43650-A) WITH DOUBLE SEAL
- CABLE VERSION FEATURES ROUND POLYURETHANE JACKET AND OVERMOLDED END TO PREVENT WICKING
- MOTOR HEAD IS SEALED AND WELDED TO IP67
- QUICK RELEASE MOTOR HEAD ALLOWS MANUAL VALVE OPERATION
- GEARBOX USES DOUBLE WALL CONSTRUCTION TO ADD STRENGTH AND ENSURE PERMANENT LUBRICATION
- ALL METAL GEARS FOR STRENGTH AND DURABILITY
- AUTOMATIC RESETTABLE FUSE (DISCONNECT POWER FOR 20 SECONDS TO RESET)
- AVAILABLE FOR NEGATIVE OR POSITVE SWITCHED SPRAYER CONTROLS
- BEC STYLE MOTOR USES A SINGLE POLE, SINGLE THROW SWITCH; BE STYLE MOTOR USES A DOUBLE POLE, DOUBLE THROW SWITCH
- INLET AND OUTLET CONNECTIONS AVAILABLE IN 3/4" OR 1" FEMALE THREADS (NPT OR BSPT), 50-SERIES FLANGE OR QUICK CONNECT
- STAINLESS STEEL STEM AND CHOICE OF STAINLESS STEEL OR POLYPROPYLENE BALL PROVIDE EXCELLENT CHEMICAL RESISTANCE
- DIRECT COUPLED VISUAL INDICATOR TO VERIFY POSITION/OPERATION
- ON 3-WAY VALVES INLET IS SIDE PORT, OUTLET IN "OFF" POSITION IS RIGHT-HAND PORT, OUTLET IN "ON" POSITION IS LEFT-HAND PORT (WHEN VIEWED WITH INLET FACING OPERATOR)





ORDERING INFORMATION:

344BEC-24-C - 0.5-METER CABLE CONNECTION, 1" NPT OUTLETS, POSTIVELY SWITCHED, 2-WAY VALVE

344BEC-23-C - DIN CONNECTION, 3/4" NPT OUTLETS, POSITIVELY SWITCHED, 2-WAY VALVE

SEE DATA SHEETS 56600 & 50515 FOR COMPLETE ORDERING INFORMATION

NOTE: DIN CABLES ARE AVAILABLE AND MAY BE ORDERED SEPARATELY.

TEFLON® IS A TRADEMARK OF DUPONT COMPANY
VITON® IS A TRADEMARK OF DUPONT DOW ELASTOMERS

WIRING CHART FOR BE & BEC MOTORS

DIN TERMINAL	WIRE COLOR	BEC MOTOR	BE MOTOR*
1	RED	CONSTANT +12VDC	+12VDC TO OPEN
2	WHITE	SWITCHED +12VDC	NOT USED
3	GREEN	NOT USED	NOT USED
FLAT	BLACK	GROUND	-12VDC TO OPEN

*NOTE: FOR BE MOTORS REVERSE POLARITY TO CLOSE. REQUIRES DPDT SWITCH.

DESCRIPTION:
344BE AND 344BEC DIRECTOVALVE® ELECTRIC SHUT-OFF BALL VALVES

Spraying Systems Co.®
Spray Nozzles and Accessories
P.O. Box 7900 – Wheaton, Il. 60189-7900

Rev. No. 1	DATA SHEET **344BEC**
Ref.	SHEET OF

ASC # 32519
Quick TeeJet Nozzle Body Assembly
Diaphragm Check Valves

3/4" Single Hose

Add this item to your order

✔ means 'In Stock'

Item No.	Description	Qty	Your Price
32519	5056087(22251-311-750-NYB)SNGL SHANK DIAPHRAGM CHK	0	4.49

ASC # 32518
Quick TeeJet Nozzle Body Assembly
Diaphragm Check Valves

3/4" Double Hose

Add this item to your order

✔ means 'In Stock'

Item No.	Description	Qty	Your Price
32518	5056090(22252-312-750-NYB) DBL SHANK DIAPHRAGM CHK	0	4.49

ASC # 28767
Cap & Gasket Nozzle Body Assembly

Quick TeeJet
Cap Blue for TK Flood, TX & TG Cone Tips

Add this item to your order

✔ means 'In Stock'

Item No.	Description	Qty	Your Price
28767	CP25608-4-NYR BLUE Q. C. CAP & GASKET ASSY.	0	0.69

ASC # 22640
Boom Clamp
Metal & Plastic

* 1" sq. metal boom clamp
* Fits 11/16" threaded nozzle bodies

Add this item to your order

✔ means 'In Stock'

Item No.	Description	Qty	Your Price
22640	BC100 1" SQUARE QC METAL BOOM CLAMP C/O 2 PCS	0	1.29

FloodJet® Wide Angle Flat Spray Tips

How to order: Specify tip number.
Examples:

- TK-VS5 – Stainless Steel with VisiFlo® color-coding
- TKT-VP3 – Polymer
- (B)1/4K-5 – Brass
- TK-SS5 – Stainless Steel
- (B)1/8K-SS5 – Stainless Steel
- QCK-SS100 – Stainless Steel with VisiFlo color-coding

(B)1/4K FloodJet (1/8" – 1" NPT) | QCK Quick FloodJet® | TKT Turbo FloodJet® | TK FloodJet

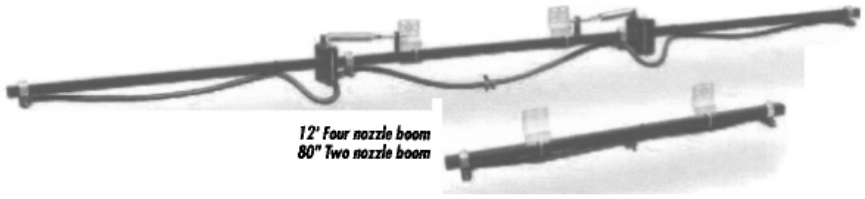
	PSI	GPM	GPA 40° 4 MPH	5 MPH	6 MPH	8 MPH	10 MPH	12 MPH	15 MPH	20 MPH
1/8K-.50 TK-.50 (100)	10	0.050	-	-	-	-	-	-	-	-
	20	0.071	2.6	2.1	1.8	1.3	1.1	0.88	0.70	0.53
	30	0.087	3.2	2.6	2.2	1.6	1.3	1.1	0.86	0.65
	40	0.10	3.7	3.0	2.5	1.9	1.5	1.2	0.99	0.74
1/8K-.75 TK-.75 (100)	10	0.075	2.8	2.2	1.9	1.4	1.1	0.93	0.74	0.56
	20	0.11	4.1	3.3	2.7	2.0	1.6	1.4	1.1	0.82
	30	0.13	4.8	3.9	3.2	2.4	1.9	1.6	1.3	0.97
	40	0.15	5.6	4.5	3.7	2.8	2.2	1.9	1.5	1.1
1/8K-1 TK-1 (100)	10	0.10	3.7	3.0	2.5	1.9	1.5	1.2	0.99	0.74
	20	0.14	5.2	4.2	3.5	2.6	2.1	1.7	1.4	1.0
	30	0.17	6.3	5.0	4.2	3.2	2.5	2.1	1.7	1.3
	40	0.20	7.4	5.9	5.0	3.7	3.0	2.5	2.0	1.5
1/8K-1.5 TK-1.5 (50)	10	0.15	5.6	4.5	3.7	2.8	2.2	1.9	1.5	1.1
	20	0.21	7.8	6.2	5.2	3.9	3.1	2.6	2.1	1.6
	30	0.26	9.7	7.7	6.4	4.8	3.9	3.2	2.6	1.9
	40	0.30	11.1	8.9	7.4	5.6	4.5	3.7	3.0	2.2
[1/8K, 1/4K, TK]-2 TK-2 (50)	10	0.20	7.4	5.9	5.0	3.7	3.0	2.5	2.0	1.5
	20	0.28	10.4	8.3	6.9	5.2	4.2	3.5	2.8	2.1
	30	0.35	13.0	10.4	8.7	6.5	5.2	4.3	3.5	2.6
	40	0.40	14.9	11.9	9.9	7.4	5.9	5.0	4.0	3.0
[1/8K, 1/4K, TK]-2.5 TK-2.5 (50)	10	0.25	9.3	7.4	6.2	4.6	3.7	3.1	2.5	1.9
	20	0.35	13.0	10.4	8.7	6.5	5.2	4.3	3.5	2.6
	30	0.43	16.0	12.8	10.6	8.0	6.4	5.3	4.3	3.2
	40	0.50	18.6	14.9	12.4	9.3	7.4	6.2	5.0	3.7
[1/8K, 1/4K, TK]-3 [TK, TKT]-3 (50)	10	0.30	11.1	8.9	7.4	5.6	4.5	3.7	3.0	2.2
	20	0.42	15.6	12.5	10.4	7.8	6.2	5.2	4.2	3.1
	30	0.52	19.3	15.4	12.9	9.7	7.7	6.4	5.1	3.9
	40	0.60	22	17.8	14.9	11.1	8.9	7.4	5.9	4.5
[1/8K, TK]-4 (50) TK-4 (50)	10	0.40	14.9	11.9	9.9	7.4	5.9	5.0	4.0	3.0
	20	0.57	21	16.9	14.1	10.6	8.5	7.1	5.6	4.2
	30	0.69	26	20	17.1	12.8	10.2	8.5	6.8	5.1
	40	0.80	30	24	19.8	14.9	11.9	9.9	7.9	5.9
[1/8K, 1/4K, TK]-5 [TK, TKT]-5 (50)	10	0.50	18.6	14.9	12.4	9.3	7.4	6.2	5.0	3.7
	20	0.71	26	21	17.6	13.2	10.5	8.8	7.0	5.3
	30	0.87	32	26	22	16.1	12.9	10.8	8.6	6.5
	40	1.00	37	30	25	18.6	14.9	12.4	9.9	7.4
[1/8K, 1/4K, TK]-7.5 TK-7.5 (50)	10	0.75	28	22	18.6	13.9	11.1	9.3	7.4	5.6
	20	1.06	39	31	26	19.7	15.7	13.1	10.5	7.9
	30	1.30	48	39	32	24	19.3	16.1	12.9	9.7
	40	1.50	56	45	37	28	22	18.6	14.9	11.1
[1/8K, 1/4K, TK]-10 TK-10 (50)	10	1.00	37	30	25	18.6	14.9	12.4	9.9	7.4
	20	1.41	52	42	35	26	21	17.4	14.0	10.5
	30	1.73	64	51	43	32	26	21	17.1	12.8
	40	2.00	74	59	50	37	30	25	19.8	14.9
[1/8K, 1/4K]-12	10	1.20	45	36	30	22	17.8	14.9	11.9	8.9
	20	1.70	63	50	42	32	25	21	16.8	12.6
	30	2.08	77	62	51	39	31	26	21	15.4
	40	2.40	89	71	59	45	36	30	24	17.8
[1/8K, 1/4K]-18	10	1.80	67	53	45	33	27	22	17.8	13.4
	20	2.55	95	76	63	47	38	32	25	19
	30	3.12	116	93	77	58	46	39	31	23
	40	3.60	134	107	89	67	53	45	36	27
[1/8K, 1/4K]-20 TK-20 QCK-20	10	2.00	74	59	50	37	30	25	19.8	14.9
	20	2.83	105	84	70	53	42	35	28	21
	30	3.46	128	103	86	64	51	43	34	26
	40	4.00	149	119	99	74	59	50	40	30
1/4K-22	10	2.20	82	65	54	41	33	27	22	16.3
	20	3.11	115	92	77	58	46	38	31	23
	30	3.81	141	113	94	71	57	47	38	28
	40	4.40	163	131	109	82	65	54	44	33
1/4K-24	10	2.40	89	71	59	45	36	30	24	17.8
	20	3.39	126	101	84	63	50	42	34	25
	30	4.16	154	124	103	77	62	51	41	31
	40	4.80	178	143	119	89	71	59	48	36

	PSI	GPM	GPA 60° 4 MPH	5 MPH	6 MPH	8 MPH	10 MPH	12 MPH	15 MPH	20 MPH
1/4K-27	10	2.70	67	53	45	33	27	22	17.8	13.4
	20	3.82	95	76	63	47	38	32	25	18.9
	30	4.68	116	93	77	58	46	39	31	23
	40	5.40	134	107	89	67	53	45	36	27
3/8K-30 TK-30 QCK-30	10	3.00	74	59	50	37	30	25	19.8	14.9
	20	4.24	105	84	70	52	42	35	28	21
	30	5.20	129	103	86	64	51	43	34	26
	40	6.00	149	119	99	74	59	50	40	30
3/8K-35	10	3.50	87	69	58	43	35	29	23	17.3
	20	4.95	123	98	82	61	49	41	33	25
	30	6.06	150	120	100	75	60	50	40	30
	40	7.00	173	139	116	87	69	58	46	35
[3/8K, 1/2K]-40 QCK-40	10	4.00	99	79	66	50	40	33	26	19.8
	20	5.66	140	112	93	70	56	47	37	28
	30	6.93	172	137	114	86	69	57	46	34
	40	8.00	198	158	132	99	79	66	53	40
3/8K-45	10	4.50	111	89	74	56	45	37	30	22
	20	6.36	157	126	105	79	63	52	42	31
	30	7.79	193	154	129	96	77	64	51	39
	40	9.00	223	178	149	111	89	74	59	45
1/2K-50 QCK-50	10	5.00	124	99	83	62	50	41	33	25
	20	7.07	175	140	117	87	70	58	47	35
	30	8.66	214	171	143	107	86	71	57	43
	40	10.0	248	198	165	124	99	83	66	50
1/2K-60 QCK-60	10	6.00	149	119	99	74	59	50	40	30
	20	8.49	210	168	140	105	84	70	56	42
	30	10.4	257	206	171	129	103	86	69	51
	40	12.0	297	238	198	149	119	99	79	59
1/2K-70	10	7.00	173	139	116	87	69	58	46	35
	20	9.90	245	196	163	123	98	82	65	49
	30	12.1	300	240	200	150	120	100	80	60
	40	14.0	347	277	231	173	139	116	92	69
[1/2K, 3/4K]-80 QCK-80	10	8.00	198	158	132	99	79	66	53	40
	20	11.3	280	224	186	140	112	93	75	56
	30	13.9	344	275	229	172	138	115	92	69
	40	16.0	396	317	264	198	158	132	106	79
[1/2K, 3/4K]-90	10	9.00	223	178	149	111	89	74	59	45
	20	12.7	314	251	210	157	126	105	84	63
	30	15.6	386	309	257	193	154	129	103	77
	40	18.0	446	356	297	223	178	149	119	89
3/4K-100 QCK-100	10	10.0	248	198	165	124	99	83	66	50
	20	14.1	349	279	233	174	140	116	93	70
	30	17.3	428	343	285	214	171	143	114	86
	40	20.0	495	396	330	248	198	165	132	99
3/4K-110	10	11.0	272	218	182	136	109	91	73	54
	20	15.6	386	309	257	193	154	129	103	77
	30	19.1	473	378	315	236	189	158	126	95
	40	22.0	545	436	363	272	218	182	145	109
[1/2K, 3/4K]-120 QCK-120	10	12.0	297	238	198	149	119	99	79	59
	20	17.0	421	337	281	210	168	140	112	84
	30	20.8	515	412	343	257	206	172	137	103
	40	24.0	594	475	396	297	238	198	158	119
3/4K-140	10	14.0	347	277	231	173	139	116	92	69
	20	19.8	490	392	327	245	196	163	131	98
	30	24.2	599	479	399	299	240	200	160	120
	40	28.0	693	554	462	347	277	231	185	139
QCK-150	10	15.0	371	297	248	186	149	124	99	74
	20	21.2	525	420	350	262	210	175	140	105
	30	26.0	644	515	429	322	257	215	172	129
	40	30.0	743	594	495	371	297	248	198	149
3/4K-160	10	16.0	396	317	264	198	158	132	106	79
	20	22.6	559	447	373	280	224	186	149	112
	30	27.7	686	548	457	343	274	229	183	137
	40	32.0	792	634	528	396	317	264	211	158
3/4K-180 QCK-180	10	18.0	446	356	297	223	178	149	119	89
	20	25.5	631	505	421	316	252	210	168	126
	30	31.2	772	618	515	386	309	257	206	154
	40	36.0	891	713	594	446	356	297	238	178
3/4K-210 QCK-210	10	21.0	520	416	347	260	208	173	139	104
	20	29.7	735	588	490	368	294	245	196	147
	30	36.4	901	721	601	450	360	300	240	180
	40	42.0	1040	832	693	520	416	347	277	208

Note: Always double check your application rates.
Other spray angles, capacities, and materials may be available.
See your TeeJet Dealer or www.teejet.com for more information.

(B) = BSPT

80", 12' & 18' BOOMS



12' Four nozzle boom
80" Two nozzle boom

***Boom** without Plumbing*

12' Boom without Plumbing	**DB12B**	25 lbs.	$119.00
18' Boom without Plumbing	**DB18B**	35 lbs.	$171.00

***Boom** with Plumbing 40" spacing*

80" Boom (2 nozzles)	**80B25**	10 lbs.	$70.00
12' Boom (4 nozzles)	**DB12**	27 lbs.	$155.00
18' Boom (6 nozzles)	**DB18**	38 lbs.	$219.00

21', 28', 30' & 40' TRUSS-T BOOMS

FEATURES:

- Designed to meet the requirements of small acreage spraying.
- Vertical and horizontal breakaway minimizes needless wear and tear. Eliminates the lashing associated with a chain boom.
- All hose is ½" EPDM chemical resistant rubber.
- Demco's Truss-T booms are available on 110, 150 & 300 gallon trailer sprayers and 55, 85, 150 & 200 gallon rear mounts. (Feeder lines not included.)

NOTE: 21', 28' & 30' booms are partially preassembled.
NOTE: 40' boom is shipped unassembled.

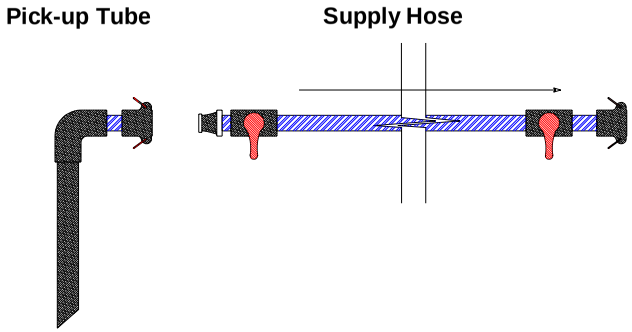
***Boom** with Plumbing*
NOTE:Order Spray Tips separately (see Pages 74-76)

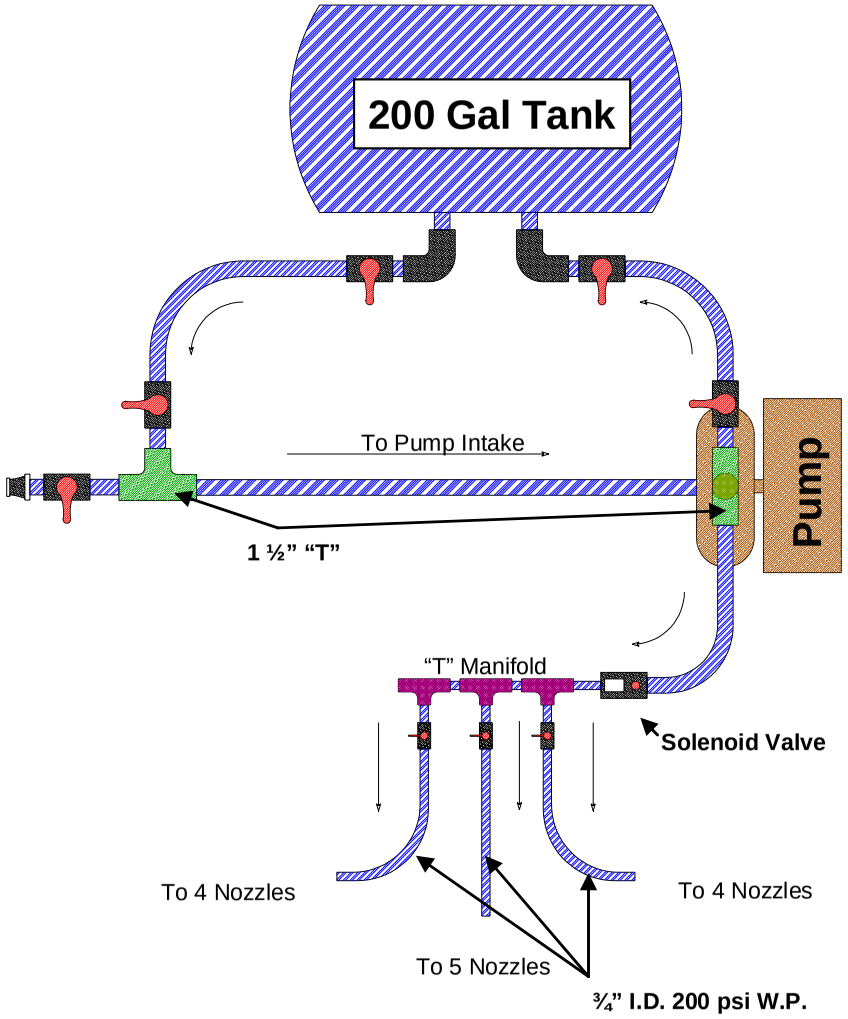
21' Truss-T boom (without plumbing) *Transport width 8*	**DB21TB**	85 lbs.	$389.00
28' Truss-T boom (without plumbing) *Transport width 8*	**DB28TB**	110 lbs.	$435.00
30' Truss-T boom (without plumbing) *Transport width 8*	**DB30TB**	115 lbs.	$457.00
40' Truss-T boom (without plumbing) *Transport width 10*	**DB40TB**	170 lbs.	$689.00
21' Truss-T boom (13 conventional nozzles) *Transport width 8*	**DB21T**	85 lbs.	$464.00
28' Truss-T boom (17 conventional nozzles) *Transport width 8*	**DB28T**	110 lbs.	$530.00
30' Truss-T boom (19 conventional nozzles) *Transport width 8*	**DB30T**	115 lbs.	$553.00
40' Truss-T boom (25 conventional nozzles) *Transport width 10*	**DB40T**	170 lbs.	$820.00
21' Truss-T boom (13 TeeJet® drip free nozzles) *Transport width 8*	**DB21TDF**	85 lbs.	$627.00
28' Truss-T boom (17 TeeJet® drip free nozzles) *Transport width 8*	**DB28TDF**	110 lbs.	$738.00
30' Truss-T boom (19 TeeJet® drip free nozzles) *Transport width 8*	**DB30TDF**	115 lbs.	$787.00
40' Truss-T boom (25 TeeJet® drip free nozzles) *Transport width 10*	**DB40TDF**	170 lbs.	$1,052.00

Accessories
Order Spray Tips separately (see Pages 74-76)

Convert a 21' Boom to a 28' Boom with Conventional Nozzles	**DB28TEX**	25 lbs.	$79.00
Convert a 21' Boom to a 28' Boom with TeeJet® Drip Free Nozzles	**DB28TEXDF**	25 lbs.	$117.00
Convert a 21' Boom to a 28' Boom without Plumbing	**DB28TEXB**	22 lbs.	$61.00
Convert a 21' Boom to a 30' Boom with Conventional Nozzles	**DB30TEX**	30 lbs.	$91.00
Convert a 21' Boom to a 30' Boom with TeeJet® Drip Free Nozzles	**DB30TEXDF**	30 lbs.	$171.00
Convert a 21' Boom to a 30' Boom without Plumbing	**DB30TEXB**	26 lbs.	$68.00

Toolcat Pump Set-up





LEGEND

- 1 ½ " "T"
- 1 ½ " Elbow
- 1 ½ " Banjo Valve
- ¾ " "T"
- ¾" Ball Valve
- 1 ½ " Male Quick Disconnect
- 1 ½ " Female Quick Disconnect

APPENDIX B
LIST OF SOURCES FOR BLADDERS, TANKS, AND TRAILERS

AG Spray Equipment, Inc.
1-800-227-4098
www.agspray.com

Detergent Containers, Inc.
1-800-346-7867
www.detergentcontainers.com

Diverse
www.plastictanks.ca

Elastec, Inc.
1-321-636-5783
www.elastec.com

Interstate Product, Inc.
1-800-474-7294
www.interstateproducts.com

Kennco Manufacturing,Inc.
1-800-645-2591
www.kenncomfg.com

Newton Crouch, Inc.
1-877-605-0273
www.newtoncrouch.com

Norwesco, Inc
1-952-446-1945
www.norwesco.com

PBM Supply & Mfg, Inc.
1-800-688-1334
www.pbmsprayers.com

Plastic-Mart
1-866-310-2556
www.plastic-mart.com

Water Tanks.com
1-877-655-1100
www.watertanks.com

CHEMTEK INC -- AVION 50 -- 6850-00F029465

========== Product Identification ==========

Product ID:AVION 50
MSDS Date:10/20/1988
FSC:6850
NIIN:00F029465
MSDS Number: BRWJW
=== Responsible Party ===
Company Name:CHEMTEK INC
Address:4900 PROSECTUS DR
Box:14013
City:RESEARCH TRIANGLE
State:NC
ZIP:27709
Country:US
Info Phone Num:800-672-8536
Emergency Phone Num:919-544-9223/800-672-8536
CAGE:0M2U7
=== Contractor Identification ===
Company Name:CHEMTEK INC
Address:4900 PROSECTUS DR
Box:City:RESEARCH TRIANGLE
State:NC
ZIP:27709
Country:US
Phone:800-672-8536
CAGE:0M2U7

========== Composition/Information on Ingredients ==========

Ingred Name:SODIUM HYDROXIDE, CAUSTIC SODA, LYE
CAS:1310-73-2
RTECS #:WB4900000
Other REC Limits:2MG/M3 CEILING NIOSH
OSHA PEL:2 MG/M3
ACGIH TLV:C 2 MG/M3; 9293
EPA Rpt Qty:1000 LBS
DOT Rpt Qty:1000 LBS

Ingred Name:2-BUTOXYETHANOL (ETHYLENEGLYCOL MONOBUTYL ETHER), BUTYL
CELLOSOLVE, BUTYL GLYCOL, GLYCOL ETHER EB
CAS:111-76-2
RTECS #:KJ8575000
Other REC Limits:25 PPM (SKIN)
OSHA PEL:S, 50 PPM
ACGIH TLV:S, 25 PPM; 9293

========== Hazards Identification ==========

Routes of Entry: Inhalation:YES Skin:YES Ingestion:NO
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:INHALATION: UNCONSCIOUSNESS. SKIN:
BURNS. INGESTION: SERIOUS DAMAGE TO THE MUCOUS MEMBRANES
W/PERFORATION OR SCARRING. EYES: BURNS. CORROSIVE TO DELICATE
TISSUE. PROLONGED CONTACT HAS A DESTRUCTIVE EF FECT UPON TISSUE.
Explanation of Carcinogenicity:NONE
Effects of Overexposure:INHALATION: HEADACHE, DIZZINESS, POSSIBLE
CHOKING, NAUSEA, POSSIBLE UNCONSCIOUSNESS. SKIN: BURNS. INGESTION:
SERIOUS DAMAGE TO THE MUCOUS MEMBRANES W/PERFORATION OR SCARRING.
EYES: SMALL BURNS.

========== First Aid Measures ==========

First Aid:EYES: FLUSH W/WATER FOR AT LEAST 15 MINS. SKIN: FLUSH

W/PLENTY OF WATER, THEN VINEGAR & WASH W/SOAP & WATER. INHALATION: REMOVE TO FRESH AIR. INGESTION: GIVE PLENTY OF MILK OR WATER. DON'T INDUCE VOMI TING. NEVER GIVE ANYTHING TO DRINK TO AN UNCONSCIOUS PERSON. OBTAIN MEDICAL ATTENTION IN ALL CASES.

========== Fire Fighting Measures ==========

Flash Point:NONE
Extinguishing Media:DRY FOAM, CHEMICAL, CO2
Fire Fighting Procedures:USE SELF CONTAINED BREATHING APPARATUS.

========== Accidental Release Measures ==========

Spill Release Procedures:DILUTE WELL W/WATER, THEN ABSORB IN CLOTH OR NEUTRALIZE W/DILUTE ACID & FLUSH TO SEWER.

========== Handling and Storage ==========

Handling and Storage Precautions:STORE AT TEMPERATURES ABOVE FREEZING & BELOW 105F. ALWAYS STORE UNUSED PORTION IN ORIGINAL CONTAINER W/CAP SECURE.
Other Precautions:AVOID SKIN & EYE CONTACT.

========== Exposure Controls/Personal Protection ==========

Respiratory Protection:USE NIOSH APPROVED RESPIRATOR, FULL FACE IF CONCENTRATION EXCEEDS TLV (S).
Ventilation:PROVIDE SUFFICIENT VENTILATION TO MAINTAIN EXPOSURE BELOW RECOMMENDED TLV
Protective Gloves:RUBBER
Eye Protection:SPLASH PROOF GOGGLES
Other Protective Equipment:STANDARD WORK CLOTHING
Supplemental Safety and Health

========== Physical/Chemical Properties ==========

Boiling Pt:B.P. Text:212-217F
Melt/Freeze Pt:M.P/F.P Text:20-30F
Vapor Density:>1
pH:>13
Evaporation Rate & Reference:(ETHER=1): <1
Solubility in Water:COMPLETE
Appearance and Odor:YELLOW LIQUID, ODORLESS

========== Stability and Reactivity Data ==========

Stability Indicator/Materials to Avoid:YES
ACID SOLUTIONS, HYDROCHLORIC ACID, REACTIVE METALS
Stability Condition to Avoid:EXTREME HEAT OR PRESSURE
Hazardous Decomposition Products:EMITS ACRID SMOKE & IRRITATING FUMES

========== Disposal Considerations ==========

Waste Disposal Methods:DISPOSE OF IN ACCORDANCE W/LOCAL, STATE, & FEDERAL REGULATIONS.

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